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(54) Title of the Invention: Substrate Processing Apparatus

(57) Abstract

Purpose: There is provided a substrate processing apparatus which prevents contamination of a substrate due to a mist of a process liquid which adheres to a member which holds the substrate to be able to rotate.

Configuration: A rotary member 11 of a substrate holding unit 1 includes a plurality of supporting pins 14 which supports a substrate W and rotary holding pins 15 which regulate a horizontal location of the substrate W. The rotary member 11 is fixed to an upper end portion of a rotating shaft 2 of a motor 3 and is driven to rotate. The rotary member 11 may use a metal on the surface of which a fluoride resin is coated, or a material in which nickel-polytetrafluoroethylene is plated on the surface of an aluminum base material. A pin fixing section 17, a magnet accommodating section 19 and an installation member 22 of the rotary holding pin 15 are formed of a water-repellent resin such as polyprophelene or the like and a gap A between the fixing section 17 and the installation member 22 and a gap B between the magnet accommodating section 19 and the installation member 22 are adjusted to 0.5mm to 1.0mm.

Scope of Patent Claims

Claim 1

A substrate processing apparatus which performs a predetermined process with respect to a substrate while rotating the substrate, comprising:

a rotary member which is able to rotate;

a plurality of holding members which is installed on the rotary member to follow an outer circumferential portion of the substrate and holds the substrate in contact with the outer circumferential portion of the substrate;

driving means which drives the rotary member to rotate; and

process liquid supplying means which supplies a process liquid to the substrate which is held by the plurality of holding members,

wherein a surface of the rotary member which faces a surface of the substrate which is held by the plurality of holding members has a water-repellent property.

Claim 2

The substrate processing apparatus according to claim 1, wherein each holding member includes:

a rotating shaft which vertically extends passing through the rotary member;

an installation section which is coupled to the rotary member and supports the rotating shaft to be able to rotate;

a supporting section which is installed on an upper end portion of the rotating shaft;

a holding section which is installed on the supporting section to be eccentric with respect to the rotating shaft to be in contact with an outer circumferential edge portion of the substrate according to rotation of the supporting section; and

a magnet accommodating section which is installed in a lower end portion of the rotating shaft and accommodates a magnet which generates a magnetic force for the rotation of the supporting section,

wherein opposite surfaces of the installation section and the supporting section with reference to a gap between the installation section and the supporting section and opposite surfaces of the installation section and the magnet accommodating section with reference to a gap between the installation section and the magnet accommodating section have a water-repellent property.

Claim 3

The substrate processing apparatus according to claim 2, wherein the gap between the installation section and the supporting section and the gap between the installation section and the magnet holding section are 0.5mm to 1.0mm.

Claim 4

The substrate processing apparatus according to any one of claims 1 to 3, wherein a contact angle with respect to water in the surface of the rotary member is 70° to 180°.

Detailed Description of the Invention

[0001]

Industrial Field of Utilization

The present invention relates to a substrate processing apparatus which supplies a process liquid to a substrate while rotating the substrate and performs a predetermined process.

[0002]

Prior Art

A rotary substrate processing apparatus is used for performing a variety of processes with respect to a substrate such as a semiconductor wafer, a glass substrate for a liquid crystal display device, a glass substrate for a photo mask, a glass substrate for an optical disc or the like. For example, a rotary developing device is used for a developing process of a photosensitive film which is formed on a surface of the substrate. The developing process of the substrate using the developing device includes a developing liquid supplying process, a developing liquid holding process, a pure water cleansing process, and a drying process.

[0003]

Fig. 5 is a schematic sectional view of a developing device in the related art, which illustrates a developing liquid supplying process. In Fig. 5, the developing device includes a substrate holding unit 41 which holds a substrate W. The substrate holding unit 41 includes a rotary member 42 which is horizontally fixed to a tip end portion of a rotating shaft 50 of a motor (not shown) and is driven to rotate around the vertical shaft. A plurality of supporting pins 43 which supports a rear surface of the substrate W, and a plurality of regulating pins 44 which regulates the horizontal location of the substrate W in contact with an outer circumferential edge portion of the substrate W are installed on an upper surface of the rotary member 42.

[0004]

A developing nozzle 51 which ejects a developing liquid is installed to be able to move vertically and horizontally, above the substrate holding unit 41. The developing nozzle 51 remains at a location which is distant from the upper side of the substrate W before the developing liquid is supplied and after the developing liquid is supplied and moves upward the center portion of the substrate W when the developing liquid is supplied.

[0005]

In the developing liquid supplying process using the developing device, after the substrate W is held by the substrate holding unit 41, the substrate holding unit 41

is driven to rotate by a motor. In this state, a developing liquid 30 is ejected on the substrate W from the developing nozzle 51 which has moved the substrate W upward, and is coated and spread on the entire surface of the substrate W due to the centrifugal force generated by the rotation.

[0006]

In the developing liquid holding process, the rotation of the substrate holding unit 41 is stopped and the substrate W is stopped for a predetermined time in the state where the developing liquid 30 is coated and spread on the entire surface of the substrate W. Thus, development of a photosensitive film of the substrate W is performed.

[0007]

In the pure water cleansing process, the substrate holding unit 41 is driven to rotate again, pure water is supplied from a pure water supply nozzle (not shown) to the surface of the substrate W, and thus, the pure water cleansing on the surface of the substrate W is performed.

[0008]

In the drying process, after supply of the pure water is stopped, the substrate holding unit 41 is driven to rotate at a high speed, and the pure water is repelled from the surface of the substrate W due to the centrifugal force which is generated by the rotation. Thus, the substrate W is dried. Thereafter, the rotation of the substrate holding unit 41 is stopped and the developing process of the substrate W is stopped.

[0009]

Problems to be Solved by the Invention

In the developing liquid supplying process as shown in Fig. 5, in the state where the substrate W which is held by the substrate holding unit 41 is driven to rotate at a low speed, the developing liquid 30 is ejected to the surface of the substrate W from the developing liquid nozzle 51. If the developing liquid 30 is discharged at a large amount to uniformly cover the entire surface of the substrate W, the developing liquid 30 passes through the supporting pins 43 or the regulating pins 44 from an outer circumferential portion of the substrate W to flow down to the rotary member 42, to thereby be adhered to the outer circumferential portion of the rotary member 42.

[0010]

Thereafter, if the rotation of the substrate W is stopped, an adhering region of the developing liquid 30 which has flowed down to the rotary member 42 is widened and part of the developing liquid 30 flows down and adheres to a lower surface side of the rotary member 42.

[0011]

As described above, after the developing liquid supplying process, the pure water cleansing process is performed through the developing liquid holding process.

In the pure water cleansing process, the pure water is supplied to the surface of the substrate W, and the surface of the substrate W is cleansed. At this time, the pure water flows down to the rotary member 42 and the developing liquid 30 which has adhered to the rotary member 42 in the previous developing liquid supplying process is partially cleansed.

[0012]

However, since the pure water is supplied in the state where the substrate holding unit 41 rotates, the centrifugal force is applied outward on the pure water on the substrate W. Thus, the pure water cannot completely wash out the developing liquid 30 which is spread on the upper surface or the lower surface of the rotary member 42 in a stop period, and thus, the adhering region of the developing liquid 30 remains on the upper surface or the lower surface of the rotary member 42.

[0013]

If the substrate holding unit 41 rotates at a high speed in the dry process, the adhering region of the developing liquid becomes mist (liquid particles) and floats in a cup 45 and re-adheres to the surface of the substrate W to contaminate the substrate W. Further, if the developing liquid which is adhered to the upper surface and the lower surface of the rotary member 42 for a long time is solidified, particles (dust) due to the solidified substance of the developing liquid are generated and floated in the cup 45 to contaminate the substrate W.

[0014]

An object of the present invention is to provide a substrate processing apparatus which can prevent contamination of a substrate due to mist of a process liquid which has adhered to a member which holds the substrate to rotate.

[0015]

Means to Solve Problems and Effects of the Invention

According to a first embodiment of the present invention, a substrate processing apparatus which performs a predetermined process to a substrate while rotating the substrate, including: a rotary member which is able to rotate; a plurality of holding members which is installed on the rotary member to follow an outer circumferential portion of the substrate and holds the substrate in contact with the outer circumferential portion of the substrate; driving means which drives the rotary member to rotate; and process liquid supplying means which supplies process liquid to the substrate which is held by the plurality of holding members, and a surface of the rotary member which faces a surface of the substrate which is held by the plurality of holding members has a water-repellent property.

[0016]

In the substrate processing apparatus according to the first embodiment of the present invention, the substrate which is held on the rotary member by the plurality of

holding members is driven to rotate by the driving means. The process liquid supplying means supplies the process liquid to the substrate on the rotary member to perform the predetermined process with respect to the substrate. If a large amount of process liquid is supplied from the process liquid supplying means to the substrate, part of the process liquid flows down onto the rotary member from the substrate. The surface of the rotary member has a water-repellent property. Thus, the process liquid which has flowed down to the rotary member is repelled by the surface of the rotary member and scattered outward by the rotation of the rotary member. Accordingly, the process liquid can be obstructed from adhering to the surface of the rotary member, and thus, can be prevented from adhering to the surface of the rotary member to become mist, to thereby prevent the surface of the substrate from being contaminated.
[0017]

According to a second embodiment of the present invention, in the configuration of the substrate processing apparatus according to the first embodiment, each holding member includes: a rotating shaft which vertically extends passing through the rotary member; an installation section which is coupled to the rotary member and supports the rotating shaft to be able to rotate; a supporting section which is installed on an upper end portion of the rotating shaft; a holding section which is installed on the supporting section to be eccentric with respect to the rotating shaft to be in contact with an outer circumferential edge portion of the substrate according to rotation of the supporting section; and a magnet accommodating section which is installed in a lower end portion of the rotating shaft and accommodates a magnet which generates a magnetic force for the rotation of the supporting section. Further, opposite surfaces of the installation section and the supporting section in a gap between the installation section and the supporting section and opposite surfaces of the installation section and the magnet accommodating section in a gap between the installation section and the magnet accommodating section have a water-repellent property.
[0018]

The holding unit of each holding member is in contact with the outer circumferential edge portion of the substrate and horizontally holds the substrate. Thus, part of the process liquid which is supplied to the substrate passes through the holding unit, and flows down through the installation section, the supporting section and the magnet accommodating section. In the holding member, the gap between the installation section and the supporting section and the gap between the installation section and the magnet accommodating section are formed so that the rotating shaft can rotate with respect to the rotary member. Further, the opposite surfaces of the installation section and the supporting section with reference to the gap and the opposite surfaces of the installation section and the magnet accommodating section

with reference to the gap are formed to have a water-repellent property. Thus, the process liquid which has flowed down from the substrate is obstructed from being inserted into the gap by the water-repellent property of the surfaces. Accordingly, the process liquid can be prevented from being inserted into the gap between the installation member and the magnet accommodating section and the gap between the installation member and the supporting section, and can be prevented from becoming a mist and being scattered in the subsequent process to contaminate the substrate. Further, the process liquid can be prevented from being inserted into the respective gaps and being solidified, to thereby prevent the rotation of the rotating shaft of the holding member from being obstructed.

[0019]

According to a third embodiment of the present invention, in the configuration of the substrate processing apparatus according to the second embodiment, a gap between the installation section and the supporting section and a gap between the installation section and the magnet holding section are 0.5mm to 1.0mm.

[0020]

As the gap between the installation section and the supporting section and the gap between the installation section and the magnet holding section are set to 0.5mm to 1.0mm or less, the process liquid can be prevented from being inserted into the gaps due to the water-repellent property of the surfaces with respect to the gaps. In the case where each gap is smaller than 0.5mm, the gap between the installation section and the supporting section and the gap between the installation section and the magnet holding section become excessively small, and thus, a high accuracy is required for installing the respective members. Accordingly, the assembly process becomes difficult. Further, in the case where each gap is larger than 1.0mm, the water-repellent property of the surfaces with respect to each gap becomes reduced, and thus, the process liquid is inserted into each gap. In consideration of these problems, each gap is set as the above described value, and thus, the process liquid can be prevented from being inserted into each gap.

[0021]

According to a fourth embodiment of the present invention, in the configuration of the substrate processing apparatus according to any one of the first to third embodiments, a contact angle with respect to water in the surface of the rotary member is 70° or more and 180° or less.

[0022]

In this respect, in the case where the contact angle of the surface of the rotary member which is in contact with water is smaller than 70°, it is difficult to sufficiently repel the process liquid. Accordingly, the contact angle with respect to water is set as

70° or more and 180° or less, and thus, the process liquid which flows down to the rotary member is scattered outward to thereby prevent adhering of the process liquid.
[0023]
Embodiments

Fig. 1 is a sectional view illustrating a rotary developing device according to an embodiment of the present invention; and Fig. 2 is a plan view illustrating the developing device in Fig. 1.
[0024]

In Figs. 1 and 2, a substrate holding unit 1 includes a circular plate shaped rotary member 11. The rotary member 11 uses aluminum as a base material, and nickel-polytetrafluoroethylene is plated on a surface of the base material which faces a surface of a substrate W. A contact angle of the nickel-polytetrafluoroethylene plating with respect to water is as large as about 100°, and thus, a developing liquid can be repelled. Further, as an another example, the rotary member 11 may use alumite in which a water-repellent resin is impregnated or a metallic material such as a titanium alloy on a surface of which a fluoride resin is coated (coating treatment).
[0025]

The rotary member 11 is horizontally fixed to a tip end portion of a rotating shaft 2 of a motor 3 through an installation member 12 and is driven to rotate around a vertical axis.
[0026]

On an upper surface of the rotary member 11, an annular cover member 13 which is made of resin is formed, and a plurality of supporting pins 14 which supports a rear surface of the substrate W protrudes from an upper surface of the cover member 13.
[0027]

Further, to the rotary member 11, a plurality of rotary holding pins 15 which regulates the horizontal location of the substrate W is installed to be able to rotate around the vertical shaft. Figs. 3 (a) and 3 (b) are perspective views illustrating the rotary holding pin and the installation member. Fig. 4 is an enlarged sectional view illustrating the rotary holding pin and its surroundings in the developing device. In Figs. 3 (a) and Fig. 4, the rotary holding pin 15 includes a cylindrical pin fixing section 17, a cylindrical (rod shape) pin member 16, a connecting shaft 18 and a magnet accommodating section 19. The pin member 16 is installed on the pin fixing section 17 to be eccentric with respect to the center of the pin fixing section 17. The magnet accommodating section 19 is fixed to a lower portion of the pin fixing section 17 through the connecting shaft 18. A rod shaped permanent magnet 20 is accommodated in the magnet accommodating section 19.
[0028]

The rotary holding pin 15 is installed in the rotary member 11 by means of an installation member 22. In Fig. 3 (b), the installation member 22 has a pair of installation holes 22a and is screw-coupled with an outer circumference area of a lower surface of the rotary member 11 (see Fig. 1). The installation member 22 has a bearing accommodating section 21, and the connecting shaft 18 of a rotary holding pin 15 is inserted in a shaft hole of the bearing 23 which is accommodated in the bearing accommodating section 21. Thus, as shown in Fig. 4, the pin member 16 and the pin fixing section 17 of the rotary holding pin 15 protrude from an upper surface side of the rotary member 11, and the magnet accommodating section 19 of the rotary holding pin 15 protrudes from a lower surface side of the rotary member 11.

[0029]

In the rotary holding pin 15, the pin member 16, the pin fixing section 17, the installation member 22 and the magnet accommodating section 19 are formed of a resin of polypropylene or polytetrafluoroethylene or the like having a water-repellent property. A contact angle of the polypropylene with respect to water is about 80° and a contact angle of the polytetrafluoroethylene is 90 to 100°, which have a high water-repellent property. Thus, the adhered developing liquid can flow down while being repelled. These members may use a metallic material on a surface of which a water-repellent material such as a polytetrafluoroethylene is coated, or a metallic material in which a surface treatment is performed with graphite fluoride or the like, as well as the water-repellent resin material. The contact angle of the graphite fluoride with respect to water is 140 to 180°.

[0030]

Further, in Fig. 4, an interval d1 of a gap A which is formed between the pin fixing section 17 and the installation member 21 and an interval d2 of a gap B which is formed between the installation member 22 and the magnet accommodating section 19 are adjusted to 0.5mm to 1mm. Surfaces of the pin fixing section 17, the installation member 22 and the magnet accommodating section 19 in the respective gaps A and B have a water-repellent property. Thus, as the intervals d1 and d2 of the respective gaps are adjusted to 1mm or less, the developing liquid is repelled due to the water-repellent property of the surfaces of the members which are opposite to each other through the gaps A and B, and thus, is obstructed from passing through the gaps A and B. Accordingly, the developing liquid is inserted and stayed in the bearing holding section 21, or the developing liquid is prevented from being coated in the bearing 23 of a non-water-repellent property. Further, if the intervals d1 and d2 of the respective gaps becomes smaller than 0.5mm, a high accuracy is required for adjusting the gaps, and thus, the assembly process becomes difficult.

[0031]

An annual magnet 6 is arranged under the rotary member 11. The annular magnet 6 is fixed to a magnet supporting member 7 which is installed to be able to move up and down by means of a driving device (not shown).

[0032]

If the magnet supporting member 7 moves up, the annual magnet 6 and the permanent magnet 20 of the rotary holding pin 15 are attracted to each other, and thus, the rotary holding pin 15 rotates. Accordingly, the pin member 16 comes in contact with the outer circumferential edge portion of the substrate W and then holds the horizontal location of the substrate W. Further, if the magnet supporting member 7 moves down, the rotary holding pin 15 reversely rotates, and thus, the pin member 16 is spaced from the outer circumferential edge portion of the substrate W. With such an operation, the outer circumferential edge portion of the substrate W is held by the rotary holding pin 15 or released therefrom.

[0033]

The rotating shaft 2 of the motor 3 is formed of a hollow shaft and a back rinse nozzle 9 (see Fig. 2) for cleansing a rear surface of the substrate is inserted therein. The back rinse nozzle 9 protrudes toward the rear surface of the substrate W passing through the installation member 12. On a tip end portion of the back rinse nozzle 9, an annular truncated cone shaped cap 8 is installed. The cap 8 is installed so that a rinse liquid (pure water) which is ejected from the back rinse nozzle 9 is prevented from being inserted in the rotating shaft 2.

[0034]

Further, a developing nozzle 10 which ejects the developing liquid is installed to be able to move vertically and horizontally above the substrate holding unit 1. The developing nozzle 10 remains at a location which is distant from the upper side of the substrate W before a developing process and after the developing process, and moves above the center of the substrate W when the developing process is performed.

[0035]

Further, a hollow cup 4 is arranged to cover around the substrate holding unit 1. The cup 4 includes an upper cup 4a which is able to move vertically and a lower cup 4b which is fixed to a lower portion of the upper cup 4a. An outlet port 4c for discharging a downward flow of fresh air which moves down in the cup 4 from the upside of the developing device is installed in a lower portion of the lower cup 4b.

[0036]

In this embodiment, the rotary holding pin 15 corresponds to a holding member according to the present invention, the motor 3 corresponds to driving means, and the developing nozzle 10 corresponds to process liquid supplying means. Further, the pin member 16 of the rotary holding pin 15 corresponds to a holding section according to the present invention, the pin fixing section 17 corresponds to a

supporting section, the connecting shaft 18 corresponds to a rotating shaft, the magnet accommodating section 19 corresponds to a magnet accommodating section and the installation member 22 corresponds to an installation section.

[0037]

Next, an operation in the developing process in the developing device in Fig. 1 will be described. In the developing device, the developing process is performed while a fresh downward flow is being supplied to the inside and the outside of the cup 4 from the upside. In the developing process, the developing liquid supplying process, a developing liquid holding process, a pure water cleansing process and a drying process are sequentially performed.

[0038]

Firstly, the substrate W is mounted on the supporting pins 14 of the substrate holding unit 1. Then, the annular magnet 6 moves up so that the plurality of rotary holding pins 15 horizontally holds the substrate W.

[0039]

In the developing liquid supplying process, in the state where the substrate holding unit 1 is driven to rotate at a low speed by the motor 3, the developing liquid is ejected onto the substrate W from the developing nozzle 10. The ejected developing liquid is uniformly coated and spread on the entire surface of the substrate W.

[0040]

A relatively large amount of developing liquid is ejected from the developing nozzle 10. Thus, part of the developing liquid passes through the rotary holding pins 15 and flows down to the rotary member 11. The surfaces of the rotary holding pin 15 and the rotary member 11 have a water-repellent property. Thus, the developing liquid which has flowed down from the substrate W is scattered outward by the rotation of the substrate holding unit 1 without adhering to the surfaces of the rotary holding pin 15 and the rotary member 11.

[0041]

Further, in the developing liquid holding process, the rotation of the substrate holding unit 1 is stopped. If the substrate holding unit 1 is stopped, the annular magnet 6 moves down, and thus, the rotary holding pin 15 is in a released state. In this state, the developing liquid is stopped and held on the substrate W for a predetermined time. Thus, development of a photosensitive film of the substrate W is performed. In this case, in the state where the developing liquid is repelled without adhering to the surfaces of the rotary holding pin 15 and the rotary member 11, the developing liquid is positioned on the surface of the rotary member 11. If the centrifugal force is generated due to the rotation of the rotational member 11, the developing liquid flows down rapidly.

[0042]

Next, in the cleansing process, the annular magnet 6 moves up again, and thus, the substrate W is horizontally held by the rotary holding pins 15. Then, the substrate holding unit 1 is driven to rotate by the motor 3, and the substrate W rotates at a predetermined speed. In this cleansing process, the pure water is ejected onto the substrate W from a pure water supplying nozzle (not shown), and thus, the front surface of the substrate W is cleansed. Then, a rinse liquid (pure water) is ejected from the back rinse nozzle 9 (see Fig. 2), and thus, the rear surface of the substrate W is cleansed.

[0043]

If the cleansing process of the front surface and the rear surface of the substrate W is completed, the drying process is performed. In the drying process, the number of revolutions of the motor 3 is increased, and thus, the substrate W rotates at a high speed. Thus, the pure water which is supplied to the surface of the substrate W is repelled outward, and then, the surface of the substrate W is dried.

[0044]

In this way, as the surface of the rotary member 11 or the surface of each rotary holding pin 15 is formed to have the water-repellent property, the developing liquid is prevented from adhering thereto and from becoming a mist in the subsequent process to contaminate the surface of the substrate W. Further, the developing liquid can be prevented from being inserted into the gap between the pin fixing section 17 of the rotary holding pin 15 and the installation member 22 and the gap between the magnet holding section 19 and the installation member 22 to be solidified, thereby preventing obstruction of the rotation process of the rotary holding pins 15.

[0045]

Moreover, the developing liquid hardly adheres to the substrate holding unit 1, and thus, the substrate holding unit 1 can be maintained in a clean state, to thereby increase the period of maintenance work such as a cleansing process of the substrate holding unit 1.

Brief Description of the Drawings

Fig. 1

Fig. 1 is a sectional view illustrating a rotary developing device according to an embodiment of the present invention.

Fig. 2

Fig. 2 is a plan view illustrating the developing device in Fig. 1.

Fig. 3

Fig. 3 is a perspective view illustrating a rotary holding pin and an installation member.

Fig. 4

Fig. 4 is an enlarged sectional view illustrating a rotary holding pin in the developing device and its surroundings.

Fig. 5

Fig. 5 is a sectional view illustrating a developing device in the related art.

Description of Symbols

1 substrate holding unit
11 rotary member
14 supporting pin
15 rotary holding pin
16 pin member
17 pin fixing section
18 connecting shaft
19 magnet accommodating section
21 bearing accommodating section
22 installation member
23 bearing